Smith and Beck (now Messrs. R. and J. Beck, Ltd.). In the summary of recent researches in microscopy is an interesting description (with illustrations) of a microscope, with its oculars and objectives, used by Prof. Amici, the discoverer in 1841 of the part played by the pollen-tube in the fertilisation of flowering plants. Nothing could more forcibly illustrate the enormous advance made during the past sixty years in the manufacture of the microscope and its appliances.

Bollettino della Società Sismologica Italiana, vol. vi. 1900–1901, Nos. 2 and 3.—On the necessity and on the choice of comparable seismic apparatus, by A. Cancani (see pp. 395-6).—On the velocity of propagation of the Emilian earthquake of March 4, 1898, by G. Agamennone. The velocity is found to be about 3 km. per second, and it does not vary perceptibly with the distance from the epicentre.—Contribution to the study of the great Neapolitan earthquake of December 1857, by L. Antonio. Contains a copy of a letter written from Caggiano, close to the position assigned by Mallet to the epicentre.—New type of seismometrograph, by G. Agamennone. A reprint of a paper describing an instrument specially designed for registering the very small movements of the ground.—Notices of earthquakes recorded in Italy (March 21 to June 5, 1899), by A. Cancani, the most important being the Greek earthquakes of April 6, 15 and May 3, the Dalmatian earthquake of May 15, and distant earthquakes on March 3, April 2, 12, 13, 16, May 8 and June 5.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 21.—"On the Capacity for Heat of Water between the Freezing and Boiling Points, together with a Determination of the Mechanical Equivalent of Heat in Terms of the International Electrical Units." Experiments by the Continuous-flow Method of Calorimetry performed in the Macdonald Physical Laboratory of McGill University, Montreal. By Howard Turner Barnes, M.A.Sc., D.Sc., Joule Student. Communicated by Prof. H. L. Callendar, F.R.S.

At the Toronto meeting of the British Association in 1897, a new method of calorimetry was proposed by Prof. Callendar and the author for the determination of the specific heat of a liquid in terms of the international electrical units. At the Dover meeting in September, 1899, some of the general results obtained with the method for water over a part of the range between 0° and 100° were communicated, with a general discussion of the bearing of the experiments to the work of other observers. In the present paper the author gives a summary of the complete work, in the case of water, to determine the thermal capacity at different temperatures between the freezing and boiling points.

Theory of the Method.

If a continuous flow of liquid in a tube be made to carry off a continuously supplied quantity of heat EC, in electrical units, then after all temperature conditions have become steady

$$JsQ(\theta_1 - \theta_0)t + (\theta_1 - \theta_0)ht = ECt$$

where

J = mechanical equivalent of heat,
Q = flow of liquid per second,
s = the specific heat of the liquid,
θ_0 = the temperature of the liquid flowing into the tube,
θ_1 = the temperature of the liquid flowing out of the tube,
h = the heat loss per degree rise of temperature from the liquid flowing through,
t = the time of flow.

In the case of water, E represents the E.M.F. across an electrical heating conductor in the tube, and C the current flowing. In this case, which is treated of entirely in the present paper, Js is replaced by $4{\cdot}2(1 \pm \delta)$ where δ is a small quantity to be determined, and varies with the thermal capacity of the water, which is not exactly equal to 4·2 joules at all points of the range.

Substituting in the general equation, rearranging terms, and dividing through by t, the equation is given in the following form :—

$$4{\cdot}2Q(\theta_1 - \theta_0)\delta + (\theta_1 - \theta_0)h = EC - 4{\cdot}2Q(\theta_1 - \theta_0),$$

which is termed the general difference equation of the method. The two terms δ and h may be determined by using two values of Q, giving two equations of the form

$$4{\cdot}2Q_1(\theta_1 + \theta_0)\delta_1 + (\theta_1 - \theta_0)h = E_1C_1 - 4{\cdot}2Q_1(\theta_1 - \theta_0)$$
$$4{\cdot}2Q_2(\theta_2 - \theta_0)\delta_2 + (\theta_2 - \theta_0)h = E_2C_2 - 4{\cdot}2Q_2(\theta_2 - \theta_0).$$

For the same value of θ_0, if the electrical supply for the two flows is regulated so that $\theta_1 = \theta_2$, then $\delta_1 = \delta_2 = \delta$, and by eliminating h,

$$\delta = \frac{(E_1C_1 - 4{\cdot}2Q_1(\theta_1 - \theta_0)) - (E_2C_2 - 4{\cdot}2Q_2(\theta_1 - \theta_0))}{4{\cdot}2(Q_1 - Q_2)(\theta_1 - \theta_0)}$$

which corresponds to the mean temperature

$$\theta_0 + \frac{\theta_1 - \theta_0}{2},$$

where $(\theta_1 - \theta_0)$ is not too great.

In the present method the flow tube is of glass, about 2 mm. in diameter, connected to two larger tubes forming an inflow and an outflow tube, in which the temperature of the water is read, by a differential pair of platinum thermometers, before and after being heated by the electric current. A glass vacuum jacket surrounds the fine flow tube and a part of the inflow and outflow tubes, to reduce the heat loss as much as possible. A copper water jacket encloses the inflow tubes and vacuum jacket, in order to maintain the glass surface of the vacuum jacket always at a constant temperature equal to the inflowing water. The heat loss from the water is then the loss due to radiation from the flow tube through the vacuum jacket, and conduction from the ends of the flow tubes.

In testing the accuracy of the method, the dependence of the heat loss on the rise of temperature was found, and the dependence of the heat loss on the flow.

The results with different calorimeters and with different rises of temperature are given in the following table :—

Summary of the Specific Heat of Water from Smoothed Curve.

Temperature C.	δ	J.
5	+0·00250	4·2105
10	−0·00050	4·1979
15	−0·00250	4·1895
20	−0·00385	4·1838
25	−0·00474	4·1801
30	−0·00523	4·1780
35	−0·00545	4·1773
40	−0·00545	4·1773
45	−0·00520	4·1782
50	−0·00480	4·1798
55	−0·00430	4·1819
60	−0·00370	4·1845
65	−0·00310	4·1870
70	−0·00245	4·1898
75	−0·00180	4·1925
80	−0·00114	4·1954
85	−0·00043	4·1982
90	+0·00025	4·2010
95	+0·00090	4·2038
	Mean value	4·18876

The values of δ represent the specific heat of water in terms of a thermal unit equal to 4·2000 joules, which occurs at 9° C. It is more suitable to select a thermal unit at a more convenient part of the scale. The mean value of the mechanical equivalent of heat from these measurements over the whole range is 4·18876 joules, which is very nearly equal to the value at 16° C., which is 4·1883 joules. It seems desirable to select a unit at a temperature which, if at the same time at a convenient part of the scale, may be equal to the mean value over the whole scale. The author has in consequence adopted a unit at 16° C., and has expressed the specific heat of water in terms of this unit.

Two formulæ can be fitted very accurately over the scale. Between 5° and 37·5° C. the following expression in terms of a thermal unit at 16° is found to read,

$$S = 0{\cdot}99733 + 0{\cdot}0000035(37{\cdot}5 - t)^2 + 0{\cdot}00000010(37{\cdot}5 - t^3).$$

The same formula holds between 37·5° and 55° by simply considering all values of the cubical term positive. Above 55° the simple formula

$$S = 0{\cdot}99850 + 0{\cdot}000120(t - 55°) + 0{\cdot}00000025(t - 55)^2$$

holds with great accuracy.

Physical Society, October 26.—Dr. Lodge, President, in the chair.—The chairman read a letter from Prof. Cleveland Abbe, of the United States Coast and Geodetic Survey, stating that the *Monthly Weather Review* would be sent regularly to any member of the Physical Society expressing a wish to receive

it. On the other hand, the Chief of the Weather Bureau would at any time be glad to receive communications referring to the physics of the atmosphere.—Dr. Shelford Bidwell then exhibited some experiments illustrating phenomena of vision. The first phenomenon illustrated was that known as "Recurrent Vision." A vacuum tube, illuminated by an induction coil, was made to rotate about a horizontal axis, and was seen to be followed, at an angle of about forty degrees, by a feebly luminous reproduction of itself. A spot of white light, projected upon a screen, and caused to move slowly in a circular path, was also followed by a less luminous spot. The same effect was shown by spots of green and yellow light, but in the case of red light no ghost was visible. The phenomena of recurrent vision are due principally, if not entirely, to the action of violet nerve fibres. The next experiments related to the non-achromatism of the eye. The lenses of the eye do not constitute an achromatic combination, although under ordinary conditions a bright object is not surrounded by fringes of colour. The effects of chromatic aberration are disguised by the luminous haze which surrounds the object, produced by a defect in the eye regarded as an optical instrument. A six-rayed star, formed by cutting a hole in an opaque screen, was illuminated by a gauze-covered condenser containing an incandescent lamp. The star was fairly clearly defined, and there were no fringes. More attentive observation showed a luminous haze. This haze is formed in consequence of the cellular structure of the eye, and the brightest rays—orange, yellow and green—are chiefly instrumental in forming it. If, therefore, these rays are obstructed, the conditions are more favourable for the observation of chromatic aberration. The rays were consequently cut off by means of coloured glasses, and the general hue of the star was purple; to some it appeared bordered with dark blue, while to others (long-sighted) it appeared bordered with red. Two oblong patches, one red and the other blue-violet, and of approximately the same intensity, were then produced side by side upon a screen. An observer with very good eyesight was able, at a distance of ten feet, to focus the patches alternately with perfect distinctness. In general, the blue patch was said to be more or less blurred. With an achromatic eye it should be possible to focus both together. Dr. Bidwell then showed some lantern slides, illustrating the complex form seen when viewing a small luminous spot through a gauze-covered lens placed so as not to be in exact focus. Some experiments were performed illustrating the principle of the colour top. When a bright image is formed on the retina after a period of darkness it has, in general, a red border which lasts for a fraction of a second. A dark patch suddenly formed on a bright ground has a blue border which lasts for a similar time. These effects were attributed by Dr. Bidwell to a sympathetic action of the red nerve fibres. When the various nerve fibres occupying a limited portion of the retina are stimulated by ordinary white or yellow light, the immediately surrounding red nerve fibres are for a short period excited sympathetically, while the violet or blue and green fibres are not so excited, or in a much less degree. Again, when light is suddenly cut off from a patch in a bright field, there occurs a sympathetic insensitive reaction in the red fibres just outside the darkened patch, in virtue of which they cease for a moment to respond to the luminous stimulus; the green and violet fibres by continuing to respond uninterruptedly give rise to the sensation of a blue border. By a simple experiment it was shown that the explanation of the colour top, depending upon changes in the convexity of the eye and non-achromatism, was untenable. By the use of a strong light it is possible to get negative after-images after looking at a brightly-coloured object. These images are complementary in colour to the object, and are formed even if the object is only viewed for a fraction of a second. By means of proper illumination and a disc rotating at the proper speed, a red wafer was so arranged that, upon looking at it, it was impossible to recognise the wafer itself, but only the continuous green after-image. The Chairman expressed his interest in the last experiment, in which it was possible to see the negative after-image of an object and not the object itself. Prof. S. P. Thompson said these experiments threw a doubt on some of the accepted notions about the properties of the eye. Dr. Bidwell asks us to believe that the yellow haze is due to a cellular structure in the eye. Is there such a structure? Can it be observed with a microscope? And do its meshes correspond in magnitude with those necessary to produce the effects? By diminishing the size of the pupil the haze is diminished and the sharpness of the image is increased. The effects seem to be due to ordinary aberration. Prof. Thompson said that the achromatism of the eye was simply shown by covering half the object-glass of a telescope and viewing a bright object with it. The object then seems bordered with coloured fringes. Mr. Blakesley, referring to the colour patches used by Dr. Bidwell, pointed out that although the patches were the same distance from the lens, yet they did not possess the same magnification. The last experiment shown did away with the theory of persistence of vision, because the space between the object and the negative after-image was evidently not illuminated. Mr. Trotter asked if red and green were the only colours which gave complementary negative after-images. Dr. Bidwell, in reply, said the effect was obtainable throughout the length of the spectrum.—A paper on the concentration at the electrodes in a solution, with special reference to the liberation of hydrogen by electrolysis of a mixture of copper sulphate and sulphuric acid, was read by Dr. H. J. S. Sand. In this paper an equation has been derived for calculating the concentration at the electrode of a solution of a single salt from which the metal is being deposited under the conditions (1) that the solution is contained in a cylindrical vessel bounded by the electrodes, (2) that no convection-currents occur, and (3) that the diffusion of the salt obeys Fick's law, and its transport values are constant. This formula can be made the basis for roughly determining diffusion coefficients. In the case of mixtures, it is possible to arrive at limits for the concentration, and it has been experimentally proved that hydrogen always appears at the electrode of an acid solution of copper sulphate, in which no currents of liquid are taking place, between the limits of time for the concentration to go down to zero. The time which it takes for the hydrogen to appear can be calculated from an empirical formula, which is similar in form to the one used for a single salt. The great part played by convection-currents in determining the ratio of the two constituents given off at the electrode of an acid copper-sulphate solution, has been shown by proving experimentally that artificial stirring causes hydrogen to disappear altogether in cases where it would otherwise have presented over sixty per cent. of the equivalents carrying the current from the solution to the electrode. The Chairman drew attention to the fact that no hydrogen was liberated until all the copper had gone, and said the formula for the concentration might be used again in further investigations. Dr. Donnan asked if the time at which hydrogen was liberated had been taken as the time at which hydrogen actually made its appearance in the form of bubbles, or whether any allowance had been made for saturation. Dr. Sand said the time was taken up to the appearance of bubbles.—A paper by Dr. R. A. Lehfeldt on electromotive force and osmotic pressure was postponed until the next meeting. The meeting then adjourned until November 9.

PARIS.

Academy of Sciences, October 22.—M. Maurice Lévy in the chair.—On the convergence of meridians, by M. Hatt.—Diagnosis of gaseous supersaturation in cases of a physical order and chemical order, by M. Berthelot. A description is given of attempts made to distinguish between these two classes of phenomena by means of the calorimeter, the reactions studied being the decomposition of dilute solutions of hydrogen peroxide by addition of platinum black or of potassium permanganate. From experiments with the latter reagent, the conclusion is drawn that the considerable quantities of oxygen held in solution are held in the state of an unstable chemical compound.—The origin of atmospheric hydrogen, by M. Armand Gautier. It has been shown in previous papers that air normally contains about ·02 per cent. of free hydrogen. It has been shown that, besides being a normal product of some putrefactive fermentations, hydrogen is given off by many volcanoes, and also escapes from many mineral springs. It is found that certain granites treated *in vacuo* with phosphoric acid give about from three to four times their volume of free hydrogen. Since ammonia is always produced at the same time, the surmise is put forward that nitride of iron, Fe_6N_2, is the source of these two gases. This nitride has not been isolated from these granites, but iron nitrides have been found in the crystalline deposits of the lava fissures of Etna by Silvestri.—Observations on the development of the Onychophoræ, by M. E. L. Bouvier. The species, *Peripatopsis Sedgwicki*, is distinguished from other species of the same genus by the nutritive blastodermic vescicle on the head of its embryos, and by the different stages of the embryo found in the same female,

These facts have already been shortly noticed, but fuller details are given in the present paper.—On the topographical correction of pendulum observations, by M. J. Callet. The method suggested has been worked out for two stations, La Bérarde and Lautaret, situated in the centre of the Alps. The application of the corrections is tedious and lengthy, but the errors of the results obtained are of the same order as those inherent in the pendulum observations themselves under favourable conditions.—Observations of the Perseids, made at Athens, by M. D. Eginitis. The observations were carried out between August 5 and August 12. The meteors were of a reddish-yellow colour, of about the 5th magnitude, and possessed a large number of radiant points.—First results of researches on the recognition of the solar corona at other times than during a total eclipse by means of the calorific rays, by M. H. Deslandres. The possibility of detecting the corona with the aid of a thermo-couple having been proved during the recent total eclipse, daily observations with the same apparatus have since then been carried out at Meudon. The results, although incomplete, show that the presence of the corona can be clearly detected under ordinary conditions in this way. The observations will be continued with more sensitive apparatus.—On the convergence of the coefficients in the development of the perturbation function, by M. A. Féraud.—On the intrinsic equations of motion of a wire, and the calculation of its tension, by M. G. Floquet.—On orthogonal systems admitting a continuous group of transformations of Combescure, by M. D. Th. Egorou.—Index of refraction of bromine, by M. Ch. Rivière. The index of refraction of carefully purified bromine has been determined for temperatures between 10° and 25° for wave-lengths between 790·9 $\mu\mu$ and 592·5 $\mu\mu$, and show that bromine has very great dispersive power, that for rays between A and D at 20° being ·037, compared with ·030 for carbon bisulphide.—The law of moduli. Thermochemical moduli, by M. A. Ponsot.—On the ammoniacal arseniates of cobalt, by M. O. Ducru. The existence of three distinct salts is indicated, which can be distinguished by the pressures at which ammonia commences to be given off.—On a general method of preparation of mixed carbonates of phenols and alcohols, and on the properties of some of these esters, by M. E. Barral. Of the various methods proposed for the preparation of these mixed esters, the best results are obtained by the action of carbonyl chloride upon a solution of the phenol in alcoholic potash or soda, the reagents being all employed in molecular proportions.—Stereochemistry of nitrogen. The stereoisomeric hydrazones of ethyl pyruvate, by M. L. J. Simon. The two isomeric hydrazones are obtained simultaneously, but in unequal quantities. They differ considerably in melting points and solubilities.—Acetals of monovalent alcohols, by M. Marcel Delépine. A thermochemical paper.—On direct nitration in the fatty series, by MM. L. Bouveault and Wahl.—Partial synthesis of laudanosine, by MM. Amé Pictet and B. Athanesesco.—On the pollinisation of cleistogamous flowers, by M. Leclerc du Sablon.

DIARY OF SOCIETIES.

THURSDAY, NOVEMBER 1.

CHEMICAL SOCIETY, at 8.—Dehydrohomocamphoric Acid and its Oxidation Products: Arthur Lapworth.—Derivatives of Ethyl α-methyl-β-phenylcyanglutarate: W. Carter and W. Trevor Lawrence.—The Nitration of Acetamino-*o*-phenylacetate (diacetyl-*o*-aminophenol)—a Correction: R. Meldola, F.R.S., and Elkan Wechsler.—Rhamnazin and Rhamnetin: A. G. Perkin and J. R. Allison.—(1) Luteolin, Part III.; (2) Genistein, Part II.: A. G. Perkin and L. H. Horsfall.—Colouring Matter of the Flowers of *Delphinium consolida*: A. G. Perkin and E. J. Wilkinson.—The Action of Alkalis on the Nitro-compounds of the Paraffin Series Part II.: Wyndham R. Dunstan, F.R.S., and Ernest Goulding.—Hexachlorides of Benzonitrile, Benzamide and Benzoic Acid: F. E. Matthews.—The Influence of Solvents on the Rotation of Optically-active Compounds, Part I.: T. S. Patterson.—Note on Gallinek's Amidomethylnaphthimidazole: R. Meldola, F.R.S., and F. H. Streatfeild.—The Action of Heat on Ethyl-Sulphuric Acid: W. Ramsay and G. Rudorf.—The Amount of Chlorine in Rain-water collected at Cirencester: Edward Kinch.

RÖNTGEN SOCIETY, at 8.—Presidential Address: Dr. J. B. Macintyre.

FRIDAY, NOVEMBER 2.

GEOLOGISTS' ASSOCIATION, at 8.—Conversazione, with Exhibits of Objects and Photographs.

MONDAY, NOVEMBER 5.

SOCIETY OF CHEMICAL INDUSTRY, at 8.—Preliminary Examination of Applications for Patents: W. Lloyd Wise.—The Early Manufacture of Sulphuric and Nitric Acids: Oscar Guttmann.

TUESDAY, NOVEMBER 6.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Address by the President, Mr. James Mansergh, and presentation of medals and prizes awarded by the Council.

WEDNESDAY, NOVEMBER 7.

GEOLOGICAL SOCIETY, at 8.—Additional Notes on the Drifts of the Baltic Coast of Germany: Prof. T. G. Bonney, F.R.S., and the Rev. Edwin Hill.—On certain Altered Rocks from near Bastogne, and their Relations to others in the District: Dr. Catherine A. Raisin.

SOCIETY OF PUBLIC ANALYSTS, at 8.—The Determination of the Available Brewing Extract of Malt: Lawrence Briant.—The Definition of the Genuine Product: C. E. Cassal.—Notes on certain B.P. Tests: C. G. Moor and Martin Priest.

ENTOMOLOGICAL SOCIETY, at 8.

THURSDAY, NOVEMBER 8.

MATHEMATICAL SOCIETY, at 5.30.—Annual General Meeting.—On the Transmission of Force through a Solid: Lord Kelvin, G.C.V.O.—In a Simple Group of an Odd Composite Order every System of Conjugate Operators or Sub-groups includes more than Fifty: Dr. G. A. Miller.—Prime Functions on a Riemann Surface: Prof. A. C. Dixon. (i) Further Note on Isoscelians; (ii) On Two In-triangles which are similar to the Pedal Triangle: R. Tucker.—(i) A General Congruence Theorem relating to the Bernoullian Function; (ii) On the Residues of Bernoullian Functions for a Prime Modulus, including as Special Cases the Residues of the Eulerian Numbers and the I-numbers: Dr. Glaisher, F.R.S.—On Green's Function for a Circular Disc: H. S. Carslaw.—On the Real Points of Inflexion of a Curve: A. B. Basset, F.R.S.—On Quantitative Substitutional Analysis: A. Young.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Inaugural Address: Prof. J. Perry, F.R.S.

FRIDAY, NOVEMBER 9.

ROYAL ASTRONOMICAL SOCIETY, at 8.

CONTENTS.